Snowmaking in Austria

Greener and more sustainable than assumed?
Empirical data: Water – Energy – CO_2 Emissions

Paper for PhD – University of Innsbruck (AUT) – Preliminary findings

Günther Aigner, June 19th, 2024

1. Introduction

Snowmaking might be considered as the most prominent possibility of adapting to climate change within the ski tourism sector. Winters in Austria have warmed by 1.7 degrees Celsius since pre-industrial times (Olefs et al., 2021, p. 23). Meanwhile, the duration of snow cover periods has decreased. Since 1961, snow cover periods in the Austrian area have shortened by an average of 40 days, especially below an altitude of 1,500 meters (ZAMG, 2022).

The pressure on ski tourism has steadily increased. This has led to a deeper look into adaptation measures. And in the end, these thought processes have led to ever more efficient snowmaking systems (Steiger & Mayer, 2008).

There has been an intensive social and scientific debate about snowmaking for decades. Topics of conflict include: the use of resources (energy, water) as well as the ecological footprint of snowmaking (adaptation or maladaptation?) (Scott et al., 2022) and skiing (Die ZEIT, 2022).

This paper presents preliminary findings of a study at the University of Innsbruck (Austria), which is being written for the Management PhD program.

The research gap is (1) that there is no evidence-based study on the resource consumption of snowmaking – neither in Austria nor worldwide. And (2) there is hardly any knowledge about greenhouse gas emissions from snowmaking. This leads to the following research questions: (1) What is the annual demand for electricity and water for snowmaking in Austria? (2) What is its annual carbon footprint? (3) What are the most important key figures –on average, across Austria – that ski resort operators can use as a benchmark to improve their economic and ecological sustainability?

The underlying study in this paper aims to improve the level of knowledge on snowmaking and thus, contribute towards a more economically and ecologically sustainable development of ski tourism.

2. Project Steps

The work process began with unstructured interviews with experts from three ski areas and with Professor Robert Steiger (University of Innsbruck). The goal was to find out which parameters are best suited for a questionnaire, which was subsequently created and refined with the interviewees.

In the first part, structural data were queried – e.g. skier visits or the size of area equipped with snowmakers. The second part asked for consumption data in the form of key figures used in the literature, e.g. water and

energy consumption per hectare. The questionnaire was sent to 141 ski areas. The survey period lasted from May 2023 to April 2024. That meant 12 months of active data efforts because ski resorts seem to be very communication averse when it comes to data. During the survey process, ongoing plausibility checks were carried out, without which the study would not have made any sense. Six ski seasons were observed for the study: 5 seasons before Covid (2014/15 to 2018/19) and the first ski season after the pandemic (2022/23).

3. Sample and Methods

30 ski areas achieved a data quality that met the requirements of this study. Data from companies in 7 (out of 9) Austrian federal states were obtained. The sample covers an area of 4,253 hectares equipped with snowmakers and a ski tourism volume of 17.8 million skier visits. This volume corresponds to a share of 34.0 percent of the Austrian skier visits (WKO 2023a). The mean sea level of all mountain and valley stations in the sample: 1,439 m.

The ski areas in the sample can be classified as follows in terms of size:

- 3 of the 28 ski areas were classified as very small (under 4 kilometers of slopes)
- 3 ski areas are small (5 to 14 km)
- 10 ski areas are medium-sized (15 to 49 km)
- 7 ski areas are large (50 to 99 km)
- 7 ski areas are very large (more than 100 km of slopes)

At the end, the sample was extrapolated with the variable skier visits. The conversion from water to snow was carried out with the ratio 1:1.75.

4. Results – total numbers

The extrapolated totals from the sample:

1. The total annual water demand for technical snowmaking in Austria is 43.8 million m^3
2. The total annual energy demand for technical snowmaking in Austria is 281 GWh. A calculation by the Austrian Association of Ropeways in September 2023 led to a similar number – 205 GWh (WKO, 2023b, p. 63), whereas the estimates in scientific literature have been much higher, in the range of 355 to 950 GWh (Steiger et al. 2021, p. 115-116).
3. The total annual CO_2 emissions for technical snowmaking in Austria are 2,831 tons. This number was determined using an Austrian state greenhouse gas calculator (Umweltbundesamt 2024a). This calculates the CO2 emissions of renewable energy with 10 tons per 1 GWh and 230 tons for the standard Austrian power mix.

5. Results – key figures

This chapter contains some of the most important key figures resulting from the study:

- The total number of snowmakers in Austria is 35,924. The ratio of fan guns to lances is 48.1 to 51.9 %. This leads to a number of 17,272 fan guns and 18,652 lances.
- The number of snowmakers per hectare is 2.9.
- The number of snowmakers per 1,000 skier visits is 0.7.
- The average operating time of a snowmaker is 174 h.
- 82.4 % of the slopes are equipped with snowmakers.
- The amount of snow produced from green energy is 99.9%.
- Water per ha: 3,501 m³.
- Energy per ha: 22,449 kWh.
- Energy per 1 m³ snow: 3.7 kWh.
- Energy per skier visit: 5.3 kWh.
- 54 g of CO2 are emitted per skier visit, which is equivalent to 0.4 km driven with a gasoline powered car.

6. Discussion: Electricity and CO2

Power consumption

Snowmaking:	281 GWh
Snowmaking, cable cars and lifts:	Approx. 843 GWh

Therefore, the energy used for snowmaking corresponds to 0.44% of Austria's total energy requirement, which is 63,700 GWh (Bundesministerium für Klimaschutz 2024).

CO_2 emissions

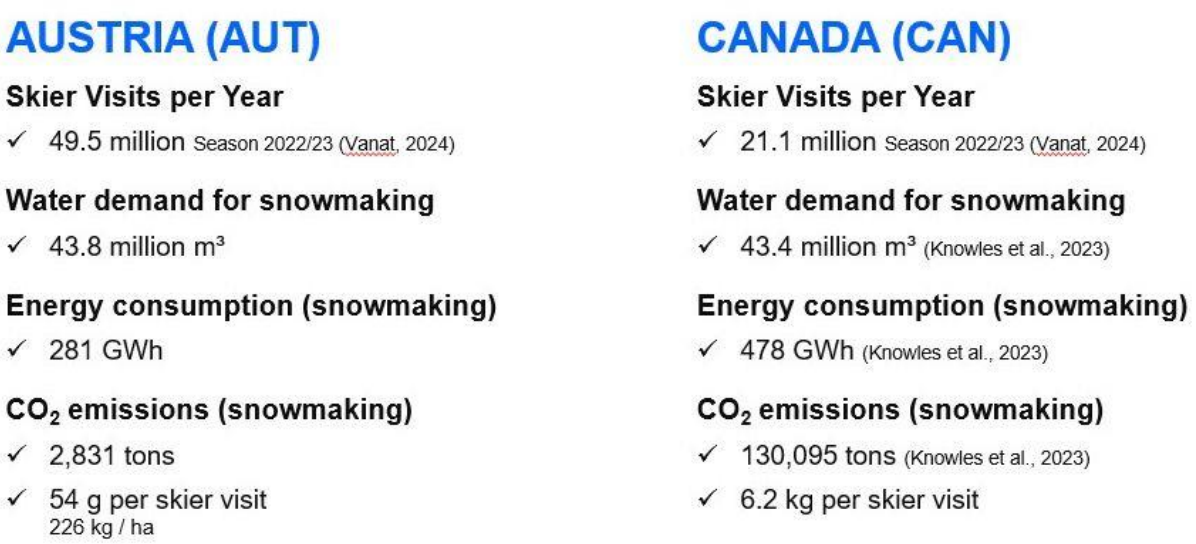
Snowmaking:	2,831 t
Snowmaking, cable cars and lifts:	Approx. 8,493 t

Therefore, the carbon footprint of snowmaking corresponds to 0.0039 % of the annual Austrian CO2 emissions of 72.8 million tons (Umweltbundesamt 2024b).

Cable cars, ski lifts and snowmaking contribute one ten thousandth to Austria’s annual CO2-emissions.

7. Discussion: Austria vs. Canada

A current study (Knowles et al., 2023) allows us to compare snowmaking in Austria and Canada.



In Canada, the CO_2 footprint of snowmaking – adjusted for skier visits – is more than 100 times higher than in Austria. Reasons for this may include a “greener” mix of electricity and more efficient snowmaking systems in Austria.

8. Discussion: Water

The average annual precipitation in Austria is 1136 mm (Chimani et al. 2016). With an area of 83,878 km² (Bundesministerium für Arbeit und Wirtschaft 2024), there is an annual rainfall of 95,285,408,000 m³.

- Water requirement for snowmaking in Austria: 43.8 million m³
- Annual rainfall in Austria: 95.3 billion m³.
- The water requirement is 0.046 % of the annual precipitation

In Austria, 4.6 ten thousandths of the annual precipitation is used for snowmaking. Another way to look at it: For every liter of precipitation, less than 5% of the volume of a thimble is used for snowmaking.
After the snow melts, this water returns to the natural water cycle completely, unchanged and drinkable. The water requirement for snowmaking is an example of a functioning circular economy.

9. Ski Season Length

This graph shows the development of ski season lengths in 14 Austrian ski areas from 1987/88 to 2018/19 (pre-covid). Snowmaking has made it possible for the length of the ski seasons to be emancipated from meteorological developments.

10. Conclusion for ski tourism

- The consumption data for snowmaking in Austria assumed in the literature appear to be too high.
- Snowmaking seems to be more sustainable and greener than expected.
- Snowmaking only makes a negligible contribution to increasing the CO2 concentration in the atmosphere. It is not an example of a maladaptation.
- Prejudices against snowmaking need to be broken down with transparent, fact-based information. Due to the lack of empirical data, the discussions of the past decades seem to have been based on emotions and assumptions.
- Both the public and scientific debate about snowmaking need an updated discussion which includes concrete data.

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